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## MUMMIFICATION, ESPECIALLY OF THE BRAIN

By D. S. LAMB

Egyptian and Peruvian cemeteries have supplied our museums with the mummified remains of those who died hundreds and even thousands of years ago. The motive for this mummification was mainly a religious one — a looking forward to a time when the body would need to be in actual evidence, lest in its absence dire disaster should befall the individual.

The story of embalming as practised by the Egyptians has been told by Herodotus, Diodorus Siculus, and many other writers, who have also described the processes used. These latter varied with the financial, social, and political status of the deceased; the circumstances of the death, including sometimes the necessity for haste in preparation for burial; the conscientiousness of the funeral director and his assistants, which was of course a variable quantity then as now; and for other reasons.

The Egyptians practised embalming from about 4000 B.C. to about 700 A.D. Everybody was embalmed—old and young, male and female, strangers and criminals,—and also many of the lower animals. Herdman<sup>1</sup> states that over 200,000 mummified animals were brought to Liverpool in 1890 and sold as fertilizer; these were mostly cats, from the great cat cemetery of central Egypt, Beni-Hasan, where formerly was a celebrated temple to Pasht, the Cat-goddess.

The substances used for embalming by the Egyptians need not be mentioned further than to say that all the aromatics of which they had knowledge were used, except frankincense, which for some reason was forbidden; bitumen, which was comparatively

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<sup>1</sup> *Proc. Liverpool Biolog. Soc.*, 1889-90, IV, pp. 95-96.

inexpensive, was used particularly for the poor, and we are told that these bitumen-preserved bodies have in later days been used largely for fuel.

We are more interested in the methods employed. The brain was usually, but not always, removed. The operator first broke down the fragile bones of the roof of the nose or, exceptionally, at the back of the orbit, by means of an iron rod with a hooked end, and then withdrew the brain in fragments either with or without its membranes; sometimes he used a stream of water to facilitate the removal. He afterward introduced into the skull cavity a preservative, usually one of the aromatics, sometimes bitumen, (the so-called *asphaltum* of the Egyptians). As much as two pounds of preservative have been found in one skull.

Prof. Alexander Macalister,<sup>1</sup> an eminent English anatomist and anthropologist, who had a large collection of mummied heads, stated that in fifty-six percent of them the brain had been extracted through the nose, and nearly twice as often through the left nostril as the right; sometimes the nasal septum was broken; twice the brain had been removed through the orbit; in some cases the membranes had been removed, in others, not. In general the operation had been only imperfectly done. In a few cases not only preservative material but also bandages had been introduced into the skull-cavity; Professor Macalister drew four yards of bandage from one nose; in another case the cavity was filled with rags. Twenty skulls had been filled with bitumen through the nose. Dr Garson<sup>2</sup> stated that in a series of twenty-three skulls of the fourth dynasty obtained by Flinders-Petrie from Medum, the brain had not been removed. Pettigrew,<sup>3</sup> mentioned that in the mummy of Kannopis the brain was found lying, in a cake-like mass, in the back part of the skull-cavity, having the impress of the bony ridge at the back of the cavity, showing that the

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<sup>1</sup> *Four. Anthropol. Institute*, XXXIII, 1893-94, pp. 115-126.

<sup>2</sup> *Ibid.*

<sup>3</sup> *History of Egyptian Mummies*, London, 1834, pp. xxi, 56.

body had been placed in a horizontal position after embalming. He had another head from Thebes showing the same thing.

Several authors have mentioned the possibility of removing the brain through the foramen magnum. Czermak suggested this, and what seemed to him to corroborate it was that the mummies from Thebes usually showed the ethmoid bone broken down, but those from Memphis only rarely. In a letter to Virchow, dated Cairo, February 21, 1897, Fouquet<sup>1</sup> mentioned finding resinous material in a skull at El Omra, but as the skull had not been perforated, the only apparent way by which the brain had been removed was by the occipital foramen. He thought, however, that this could not have been done without first cutting off the head. Virchow, commenting on Fouquet's letter, remarked that Fouquet had also unwrapped more than a hundred priest mummies of Deir-el-Bahari, (twenty-first dynasty,) in which the brain had been removed by perforating the ethmoid bone and washing out with a stream of water. Virchow had himself examined mummy skulls by coronal section which showed the destruction of the ethmoid and adjacent bones, the injury in some cases being quite extensive. He doubted if in mummies the brain had ever been removed through the spinal canal or foramen magnum, because such an operation would be attended with the greatest technical difficulties and would hardly be attempted even at the present day. Whether the masses so often found in mummy skulls are or are not brain which has dried and become changed in some thousands of years, he considered to be an open question.

There is also a letter to Virchow from Dr G. Schweinfurth,<sup>2</sup> dated Assuan, February 18, 1897, in which he remarked that in Peru the bodies were never exposed to rain; but in Abydos, Egypt, where burials were made without wrapping the body and without coffin, rain certainly did occur at intervals of every eight or ten years, as shown by the incrusta-

<sup>1</sup> *Verhand. Berlin. Gesell. f. Anthropol.*, 1897, p. 134.

<sup>2</sup> *Ibid.*, p. 131 et seq.

tions of salt on the skulls. Abydos was the location of the first dynasty; it was six miles from the west bank of the Nile and a hundred miles below Thebes. The modern name of the village is Arabat-el-Madfoon, also called Madfuneh.

Salkowski<sup>1</sup> reported to the Berlin Anthropological Society the results of his most exhaustive examinations of the contents of some Egyptian mummy skulls, in which investigation he was assisted by Dr Georg Schrader. The masses were found to be usually dark brown, were somewhat friable, and broke with a shining fracture; he obtained from them an alkaline ash, salts of phosphoric acid, resinous matter, fatty acids, and neutral fats which always gave a strong reaction of cholesterin. His conclusions were that in some cases brain matter was probably present, in others its presence was doubtful; from which Virchow was moved to question whether the material was actually brain or merely embalming material.

Of the thousands of Egyptian mummies examined in modern times, there is, so far as I know, but a single record (that of Flinders-Petrie and Quibell<sup>2</sup>) of the undoubted finding of a brain—proved to be such by the preservation of its convolutions. The burial is classed by Petrie as a contracted burial of what he calls the “New Race”; that is, the race which went into Egypt during the period between the sixth and twelfth dynasties. The cemetery was near Ballas, on the west bank of the Nile, about thirty miles north of Thebes. The period<sup>3</sup> is estimated to have been between that of the Old and Middle Kingdoms, 3300 to 3000 B.C. In the language of the observers, “the body was sharply contracted, the left arm especially being quite doubled. The brain remained in the skull, dried to a dark brown mass, rather smaller than a cricket ball, in which *the convolutions were still clearly defined*. Some fragments of wood were below the

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<sup>1</sup> Ibid., pp. 32–34, 138 et seq.

<sup>2</sup> *Nagada and Ballas*, London, 1896.

<sup>3</sup> Ibid., p. 61.

body. . . . None of the filling of the tomb had slipped under the cover.”<sup>1</sup>

I would not be understood as saying that this is the only case of the kind recorded, but it is the only one I have been able to find. In view of the fact that it is estimated that about four hundred millions of persons were embalmed in the 4700 years in which the Egyptians practised embalming, it is curious, to say the least, that there would appear to be but one such case recorded.

The most interesting question is, how this brain, an organ so very perishable under ordinary post-mortem conditions, was preserved. The conditions in this case must therefore have been quite extraordinary: the environment must have been exceptionally dry.

The great perishability of the brain is due to the large quantity of water which enters into its composition. The usual attempts to preserve it have therefore been on one of two lines—either by rapid drying or by substituting another liquid for the natural moisture. These other liquids have the quality of chemical constancy under ordinary atmospheric conditions, and some of them cause chemical and physical changes in the brain itself which delay or prevent decay—they are therefore called preservatives. Aside from the religious motive which prompted persons or peoples to attempt the preservation of the brain, this is often desirable in modern times to enable satisfactory study of the differences in the brains of individuals and of races, between those of human beings and the lower animals, and for other purposes.

The usual method by which the Egyptians preserved the remainder of the body was to make an incision in the left side of the abdomen and introduce a preservative into this cavity and the thorax, in most cases previously removing the organs contained in these cavities and treating them also with the preservative, after which they were either replaced or kept in appropriate

<sup>1</sup> Par. 23, left column of p. 15; see also pl. v, p. 23.

vessels near the mummy. There is much evidence that the body was kept many days in a solution of bitter salt; and there were many lakes of bitter water in the near-by Libyan desert. The body was finally wrapped in bandages intermingled with preservative substances; twelve hundred yards of  $3\frac{1}{4}$ -inch bandage have been unwrapped from a single mummy. The period covered by the entire process is said to have been seventy days, while the cost varied from a small sum to as much as twelve hundred dollars.

In view, then, of the great care taken by the Egyptians to preserve the body, we need not be surprised that after hundreds and even thousands of years the features are still natural in many cases. In a discussion before the Anthropological Society of Paris,<sup>1</sup> in describing the face of the mummy of an Egyptian man twenty-four or twenty-five years of age, which was found in a royal sepulcher at Deir-el-Bahari, Fouquet said that the mouth was open, with the left corner raised and the right depressed, while the limbs, like all the rest of the body, were contorted—in-disputable evidences of the last convulsions of a terrible agony, even after thousands of years. Fouquet's conclusion was that the man had died in convulsions from poisoning. The brain had been removed through the nose, but no opening had been made in the side of the body; the embalming had not been regular, and the bandaging evidently had been hurried. Here, then, was a case of medico-legal importance in which the evidence was still present after several thousand years.

J. C. Warren<sup>2</sup> described an Egyptian mummy in which there was a distortion of features from right to left, such as we see in facial paralysis. Other writers mention the natural appearance of mummies; especially Maspero<sup>3</sup> in his description of the mummy of Seti I, father of the great Rameses II, 1300 B.C. A similar

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<sup>1</sup> *Bulletin*, etc., 1886, IX, p. 582.

<sup>2</sup> *Four. Phil. and Arts*, Boston, 1823-24, I, pp. 164, 269, 2 pls.

<sup>3</sup> *Sanitary World*, London, 1886, VI, p. 5.

statement is made in regard to Rameses himself<sup>1</sup>; and Maspero mentions also a mummy of the sixteenth dynasty, 4000 to 6000 years old, in the great museum of Poulak, in which the features are still natural.

The excellent preservation of the tissues of these mummies is also shown by microscopical examination. Thus, Czermak<sup>2</sup> reported that the nails showed nuclei; the connective tissue, spindle-cell nuclei; the muscle fibers, striation; the cartilage showed cells; nerve fibers showed the axis cylinder, and fat cells were recognizable. He gave illustrations of all these. Maddox<sup>3</sup> also was able to recognize, microscopically, muscle and nerve fiber in a mummy.

The Guanches, the aboriginal people of the Canary islands, practised what was mainly a dry-air method of preservation. The bodies were sewn in skins and deposited in grottoes; after 2000 years they are in good preservation. Here may be mentioned Dalrymple's report<sup>4</sup> of two bodies preserved by resins in lead coffins in an abbey vault.

Turning to the Western hemisphere we find that the Incas mummified their dead, and are said also to have embalmed the bodies of persons of high rank, although the process of embalming was apparently nothing more than drying by heat. The bodies were usually doubled up in a sitting posture and wrapped in a number of coverings, intermingled with various articles, as coca and other leaves, wheat and other stalks, and raw cotton; and the entire mass was tied with cords. The preservation depended on the absence of rain, the consequent dryness of the earth, and the quantity of niter which the earth contained. The bodies were placed in graves from 2 to 15 feet deep; sometimes the

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<sup>1</sup> *Uncovering of the Mummy of Rameses II*, folio, Boston, 1886.

<sup>2</sup> *Beschreibung und mikroskopische Untersuchung zweier Aegyptischen Mumien*. Reprinted from October number, 1852, of session of m. n. class. der Kais. Akademie der Wiss., IX Bd., p. 427.

<sup>3</sup> *Four. Roy. Micros. Soc.*, London, 1887, pt. 4, pp. 537-544, pl.

<sup>4</sup> *Med. Quart. Rev.*, London, 1835, III, pp. 169-171.



grave was lined with a stone wall, at others with an adobe wall, but often it was simply a round or square opening made in the hard earth. Some graves had a roofing of reed cane, some of adobe, but oftener there was only a sand filling. The body was usually placed with the back to the east. It is stated by Parish<sup>1</sup> that in many cases the eyes of cuttle fish were substituted for the natural eyes of the individual.

When these mummies are unwrapped the flesh is found to be dry, brittle, and shrunken; in quite young children it is sometimes reduced to a brown powder, and only portions of the hairy scalp and the cartilaginous coverings of the joints can be recognized, the joints being separated and the bones being in a heap.

In adults the *dura mater*, i. e., the firmer covering of the brain, is generally recognizable as a dry, more or less tough and tenacious membrane, and sometimes its blood-vessels are distinct. The brain itself is usually found either as a loose, shapeless, somewhat flattened mass, or as smaller masses adherent to the several intracranial fossæ, or both. The color varies from light brown to nearly black; it has the consistence, toughness, and brittleness of ordinary resin; in its center is sometimes found a whitish, wax-like substance. The mass usually burns with a dull, smoky flame, like resin, with a blackish residue. The actual weight of the brain in one case was two ounces, probably one-twentieth of its original weight. Professor Vogel, of the University of Giessen, examined many of these masses, and reported that chemical and microscopical analyses showed them to contain brain fat and dried blood cells, with no foreign substance.<sup>2</sup> Dr W. M. Gray of the Army Medical Museum at Washington, has also examined these masses microscopically and reports that they dissolve readily in caustic potash solution and are composed of numerous cells varying in shape and size, mixed with unrecognizable granular material, with an occasional small mass of blackish pigment; macroscopically

<sup>1</sup> *Trans. Ethnolog. Soc.*, London, 1866, n. s., IV, pp. 59-60.

<sup>2</sup> *Comptes Rendus Acad. Sci.*, Paris, 1857, XLIV, p. 1204.

they break like wax and have a greasy feel. Salkowski<sup>1</sup> also examined the skull contents in one case; they consisted of a soft, brownish, friable mass mixed with some sand, and burned with a bright flame and the odor of fat and burning horn. He obtained a fatty mass by extraction with alcohol and also a strong reaction of phosphoric acid, from which he concluded that it was undoubtedly brain substance.

In no case have I seen any appearance of convolutions, although Dr G. A. Dorsey of the Field Columbian Museum, Chicago, tells me that he has seen them.

To what extent mummification was practised on this hemisphere I do not know, but I am told that the practice extended from one end to the other. In the Eastern hemisphere embalming was practised by others than the Egyptians, but not to the same extent, and the art was in many cases learned from the latter.

Many isolated instances of mummification are recorded, which, however, were accidental or at least unintentional. For instance, in arid regions the dead body, if not disturbed by predatory birds or beasts, simply mummifies; a similar condition results in the case of those overwhelmed by sandstorms. Human beings and animals imbedded in avalanches of snow, in ice or frozen earth, are preserved, but not necessarily mummified. On the top of the great St Bernard is a morgue in which are placed the bodies of unknown persons perished in the snow, and these bodies dry up. Mummified bodies have been found in the convents of the Capuchins near Palermo and at Rome, in the caves of St Michael at Bordeaux, in the church of St Thomas, Strasburg, in the vault of the Kreuzberg church, near Bonn, on the Rhine. There is also the famous case of the murder of De la Visée and his servant in Paris; the nineteen bodies of soldiers, perfectly preserved, reported by König,<sup>2</sup> and the two bodies in lead coffins, reported by Brébant.<sup>3</sup>

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<sup>1</sup> Loc. cit.

<sup>2</sup> *Pest. Med. Chir. Presse*, Budapest, 1890, xxvi, p. 691.

<sup>3</sup> *Union med. and scient. du nord*, Reims, 1886, x, pp. 290-305.

In some of these cases many years and even hundreds of years had elapsed between the time of death and the discovery of the bodies.

In view of the multitude of Indian mounds in the United States, it might be supposed that there were many instances of mummification; but they have been very rare indeed, compared with the immense number of simply dried bones which have been found. The fact that the bodies were usually committed directly to the earth of course facilitated rapid disintegration as against preservation, and much less mummification. Two instances have been recorded in which the dried brain of an ancient Indian has been preserved with sufficient distinctness to be recognized as such; one by Prof. F. W. Putnam, of the Peabody Museum, Cambridge, and the other by Prof. Warren K. Moorehead. With regard to the former, Professor Putnam<sup>1</sup> says:

Over the head was a broad piece of copper, extending from ear to ear, and over this a woven net of bark-fiber, outside of which was a braided mat of cedar bark. The action of the copper upon these fabrics and upon the scalp has preserved them, and also the hair and skin under the copper. The bones of the face and portions of the cranium are deeply stained by the copper. Even the interior of the cranium is stained green, and the action of the copper, with the favorable condition of a dry soil, has preserved a portion of the brain mass with its membranes in the form of a hard dark ball. . . . There is little likelihood that the Indian whose head has been so well preserved by the action of the copper covering was buried less than 250 years ago, and the oxidized and decayed condition of the remaining portions of the copper shows that considerable time has elapsed since the burial took place. These interesting objects were found by the workmen on the Winthrop branch of the Revere Beach and Lynn Railroad, in the town of Winthrop, Mass.

The *raison d'être* of this paper is the brain found by Prof. Warren K. Moorehead in a mound, the property of Charles Metzger, on Deer creek, about two miles southwest of Yellow Bud, a

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<sup>1</sup> 22d Report of the Trustees of Peabody Museum, vol. iv, No. 2, 1888, p. 37; also, 23d and 24th Reports, vol. iv, Nos. 3 and 4, 1891, p. 75.

post village of Union township, Ross county, Ohio. The mound was on a hill over 150 feet high, was nearly round, and was originally 40 feet high with a base diameter of 200 feet; it was of ordinary hill clay, and had been made entirely by manual labor. The ground on which it was erected had been leveled and burnt, so that it had an even floor.

Some farmers had cut the mound down from 40 to 34 feet and sunk in its center a circular shaft 8 feet in diameter to a log pen; that is, a pen made of logs which supports the overlying earth and conceals a cavity in which are usually a skeleton and other things. There were several log pens in the mound. In one place, about four feet from the bottom of the mound, was a bed of ashes from one-fourth of an inch to 3 inches in thickness, extending over an area more than 10 by 6 feet; the earth beneath the ashes was burnt a bright brick red. Near the edge of this ash bed was the end of a cedar log, 18.5 feet long and 5.4 feet in circumference, that must have been brought from some distance, because there are no cedar trees within ten miles of the mound and no tradition of any. A circle of saplings had been placed about the log somewhat in the form of a tepee. Immediately beneath the log, in an excavation two feet below the original ground surface, was a skeleton, with head to the north, arms at the sides, legs extended. Traces of hair were about the skull; the brain was dried and shrunken within the skull. Cloth, buckskin, rude matting, and bark covered the skeleton, which was discovered September 4, 1894. Professor Moorehead said: "The dry ashes with which the remains were covered and the great depth, 36 feet, from the surface, aided in the preservation of such substances as usually decay."<sup>1</sup>

In reply to inquiries, Professor Moorehead, on November 24, 1900, stated that he personally discovered the "little dried round ball" and removed it from the skull; he did not notice any

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<sup>1</sup> See account by Clarence B. Moore in *Proceedings Academy of Natural Sciences Phila.*, for 1894, pp. 314-321.

membranes, and in fact never noticed any in any other skull ; but there was some soft, fine, sand-like dirt in this cranium.

Mr Moore<sup>1</sup> says that the Metzger mound contained nothing of European manufacture and may therefore have been many hundred years old ; in his opinion it antedated the coming of white men to that part of Ohio. As the French were the first whites to enter this territory (about the year 1670), it seems safe to estimate the age of this brain at not less and probably much more than two hundred years.

I have been thus particular to give the details of the finding of this brain specimen, because Dr M. G. Miller, of Philadelphia, assistant to Mr Moore, in a letter asking if I would care to examine and report upon it, stated that he had written "to Virchow and other continental authorities, but they had never met with or heard of a human brain having been preserved by natural agencies and seemed to doubt the genuineness of the specimen."

The matter seemed to me of enough importance to be referred to the Director of the Army Medical Museum and Library, Col. A. A. Woodhull, who accordingly replied to Dr Miller, offering to have a careful examination made of the specimen, to determine its nature. Dr Miller, in behalf of Mr Moore, formally contributed it to the Museum. He also wrote that in certain crevices of the brain there were particles of a friable, whitish substance ; and material apparently similar remained on certain pieces of bone, buckskin, etc., from the same burial.

The specimen as received is in two parts, unequal in size, and with a few smaller fragments. Placed in what seemed their natural apposition, they measure together 4.3 cm. long, 4.5 cm. broad, and 2 cm. thick. The breadth of an average adult recent brain at a corresponding place is three times as great, and the difference represents the extent of shrinkage. The weight is 12.54 grams — less than half an ounce ; an average adult's brain weighs about 48 oz. The two parts are rounded anteriorly ; the upper

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<sup>1</sup> Op. cit.

surfaces are much flattened, the lower surfaces irregularly flattened; each shows posteriorly an irregular broken surface. Color, dark brown, approaching black externally; a lighter brown or tan color where the outer part is chipped away; the appearance is everywhere granular; in one or two places where the outer part has been fractured, black, glistening surfaces appear beneath. Scattered in crevices in the general surface is a small quantity of a whitish powder. All the surfaces are convoluted and the general appearance is that of a brain; the cerebellum, pons, and oblongata are absent. The above description is practically the same as that given by Colonel Woodhull in his report.

Portions of the specimen were examined by Dr Gray, who reported that they almost entirely dissolved in caustic potash, the soft residue not showing any fibrous character. Macerated portions showed cells of various shapes and sizes, consistent with tissue cells. These absorbed aniline dyes, but showed no evidence of nuclei. Some cells contained a black or dark brown pigment, undistinguishable from blood pigment, and with these were many small round cells which resembled and may have been red blood cells. No fibrous element was demonstrable. He regarded the specimen as of animal origin and probably brain.

Dr W. M. Mew, chemist, carefully examined the whitish substance associated with the specimen and found it to be phosphatic, indicating osseous or nervous tissue and excluding the possibility of its being vegetable matter.

The specimen, however, was further referred to Mr Albert F. Woods of the Division of Vegetable Physiology and Pathology in the Department of Agriculture, who reported: "We made careful micro-chemic tests as well as microscopic examination of the specimen and cannot find any evidence of the presence of vegetable tissue; in fact it seems highly probable that it is only animal tissue."

It will thus be seen that every effort was made to assure ourselves if the specimen is brain and nothing else. Some convo-

lutions and fissures are well marked ; others are obscure. Some distortion has occurred in the drying, so that an entirely satisfactory study of the fissural pattern cannot be made. This is much to be regretted, because the comparison of an average brain of to-day with a brain (presumably an average one) of an Indian of several hundred years ago would be instructive.

The study which is now being given to the brain is disclosing very much of interest and value. It may not be generally known that at Cornell University a collection of brains of moral and educated persons is being made by Prof. B. G. Wilder for the purpose of thorough study ; and thus far he has published the results of some valuable observations.